

Colony Structure of the Weaver Ant, *Oecophylla smaragdina* (Fabricius) (Hymenoptera: Formicidae)

by

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ABSTRACT

The colony structure of *Oecophylla smaragdina* within the compound of Universiti Sains Malaysia, Penang Island, Malaysia was determined. The current study involved a total of twelve nests which were taken from two different locations. Each nest was dissected and the specimens were separated according to their caste. Results show that the colony structure of *O. smaragdina* consisted of a dealate queen, eggs, larvae of female alates, pupae of major and minor workers, pupae of female alates, major workers, minor workers, female alates and male alates. Our present study shows that *O. smaragdina* had a distinct caste system and the numbers of individuals in each caste reflect their respective functions which contributed to the success of their colony.

Keywords: *Oecophylla smaragdina*; nests; caste; colony structure

INTRODUCTION

Weaver ants, or *Oecophylla*, are eusocial insects of the family Formicidae (Order: Hymenoptera). They are classified under the subfamily Formicinae. Weaver ants are obligate arboreal species and are known for their unique nest building behavior where workers construct nests by weaving together leaves using larval silk (Hölldobler & Wilson 1990). The Asian weaver ant, *O. smaragdina* is well distributed throughout most of the Oriental region from India to Queensland and the Solomon Island (Greenslade 1972). They are also common in the lowland of Peninsular Malaysia and have become an important ant in the tree canopies of the humid tropics of Southeast Malaysia, Australia, and Pacific islands (Jander & Jander 1979; Bluthgen & Fiedler 2002).

Previous studies reported the existence of single or multiple queens in the colonies of *O. smaragdina* (Greenslade 1971; Peeters & Andersen 1989;

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Hölldobler & Wilson 1983; 1990). However, little was known about the colony composition and caste system such as the existence of reproductive individuals and non-reproductive individuals of these weaver ants. Despite being well-studied for other biological attributes, the colony structure of *O. smaragdina* has received less attention (Schlüns *et al.* 2009). Studies on colony structure and caste composition might be able to explain how the social structure inside the nest influence the behaviour of individuals outside the nest. Therefore, the objective of the current study was to report the colony structure of *O. smaragdina* inside the nests of this species.

MATERIALS AND METHODS

This study was conducted in November 2010 until February 2011 at the main campus of Universiti Sains Malaysia, Penang Island, Malaysia. Two colonies of weaver ants, located 500 m from each other, were chosen for this study. The boundary of each colony was determined by following the ant trails. The first colony was located behind the “Kelas Al-Quran dan Fardu Ain” building (KAFA) and the second colony was located near the building of the School of Industrial Technology (TI). The KAFA colony made nests on five mango trees (*Mangifera indica*) whereas the TI colony made nests in a “mempari” tree (*Millettia pinnata*). Total nests sampled were twelve, where eight nests taken from the KAFA colony and four nests from the TI colony. These nests were removed from the trees by cutting the base of the nest using a long cutter (Sharpex) and placing it into plastic buckets (60 cm x 80 cm) containing cotton wads wetted with chloroform.

All nests were collected in between 10 a.m. to 12 p.m., corresponding to the time of day when the weaver ants were least active which was determined in a preliminary study. Each nest was kept separately in individual plastic buckets. These plastic buckets were brought back to the laboratory and kept inside a fume hood for 24 hours to ensure that the weaver ants were all dead. After 24 hours, the nests of *O. smaragdina* ants were dissected and sorted according to the following castes: dealate queens, egg, larvae, pupae, female alates, male alates, major workers and minor workers. The number of individuals of each caste for each nest were counted and recorded. The collected specimens were preserved in 95 % ethanol. The images of each specimen of *O. smaragdina* were

Table 1. Caste composition of *O. smaragdina* for each KAFA and TI colony (Mean \pm S.E.M./nest).

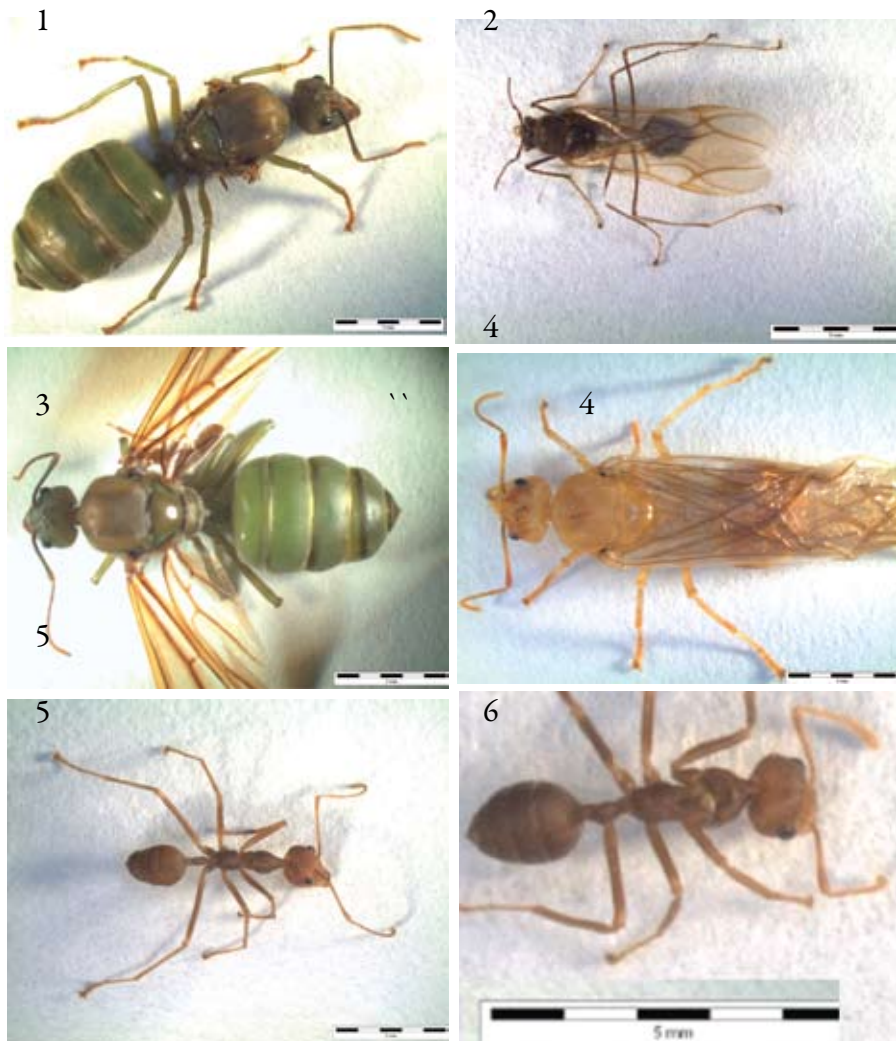
Colony	Caste system	Dealate queen	Eggs	Larvae of female alates	Pupae of workers	Pupae of female alates	Major workers	Minor workers	Female alates	Male alates
KAFA	Mean \pm		233.38	35.88	633.50	83.00	553.38	441.88	80.00	1384.38
	S.E.M./nest n=8 nests	1	± 58.79	± 10.21	± 204.85	± 20.47	± 123.82	± 79.23	± 26.09	± 367.57
TI	Mean \pm		84.00	± 10.75	91.25	44.75	390.00	193.25	11.00	0
	S.E.M./nest n=4 nests	0	± 25.69	± 5.65	± 32.87	± 16.91	± 51.15	± 19.64	± 5.08	

captured and s measurements were determined using a stereomicroscope (Olympus SZX9) which was connected to Image analyser Cell A (Dell Inc. computer). The mean number and standard error of mean (S.E.M) for each caste was determined using Statistical Packages for the Social Sciences (SPSS 11.5).

RESULTS

Table 1 shows the caste composition of *O. smaragdina* from the twelve nests sampled. One dealate queen was found in the KAFA colony (Fig. 1). The dealate queen of *O. smaragdina* found in the field was green to brown in color. In contrast, the male alates of *O. smaragdina* were black in color and smaller in size (Fig. 2). The female alates of the KAFA colony were green in color with unshed wings (Fig. 3). However, the female alates of the TI colony were yellow in color with unshed wings (Fig. 4). The major workers were bigger in size compared to minor workers (Fig. 5; Fig. 6). Table 1 also shows that the highest number in any individual caste was male alates in the KAFA colony (1384.38 ± 367.57), however no male alates were observed in the TI colony. In addition, the number of major workers was higher than the minor workers for both colonies (KAFA= 553.38 ± 123.82 ; 441.88 ± 79.23) (TI= 390.00 ± 51.15 ; 193.25 ± 19.64). Both eggs and larvae were white in color and similar in

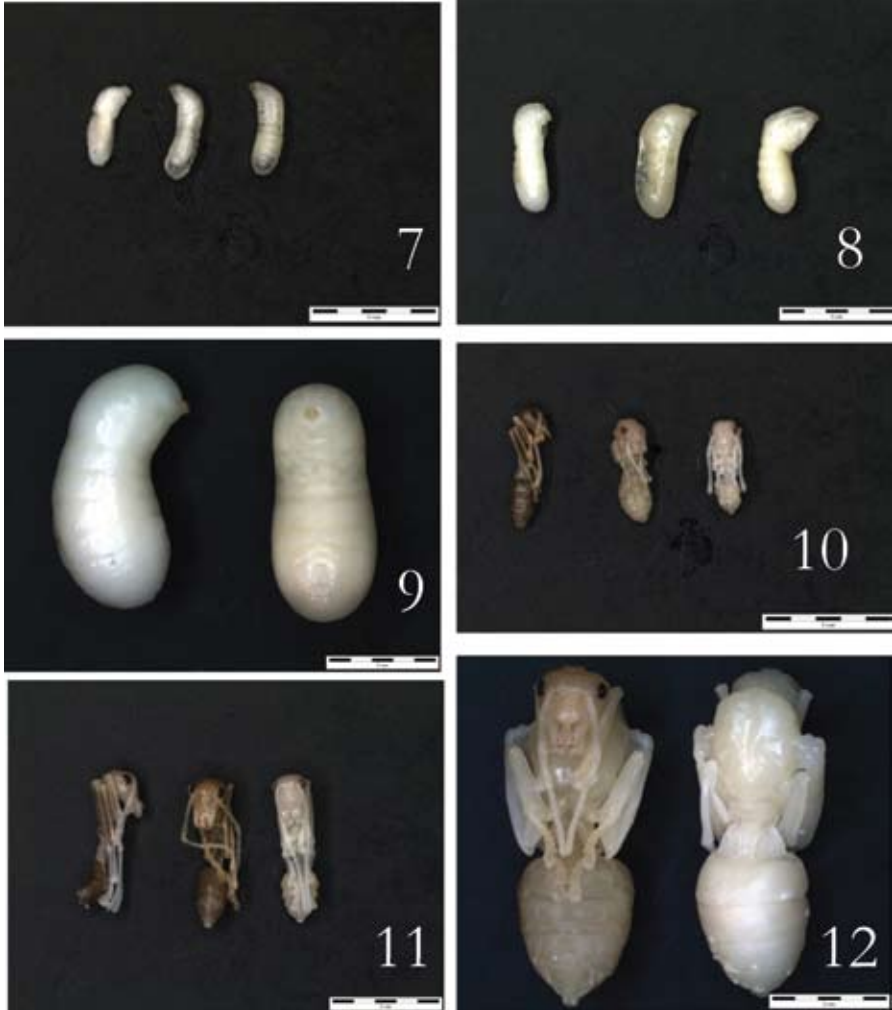
shape but the larvae were bigger in size (Fig. 7; Fig. 8; Fig. 9). The pupae had developed eyes, mouth, legs and wings that were very similar to the adults (Fig. 10; Fig. 11; Fig. 12).



Figs. 1-6: Fig. 1. Dealate queen of *O. smaragdina* from KAFA colony; Fig. 2. Male alate of *O. smaragdina* from KAFA colony; Fig. 3. Female alate of *O. smaragdina* from KAFA colony; Fig. 4. Female alate of *O. smaragdina* from TI colony; Fig. 5. Major worker of *O. smaragdina* from both colonies; Fig. 6. Minor worker of *O. smaragdina* from both colonies.

DISCUSSION

The current study showed the basic colony structure of *O. smaragdina* ants consisted of dealate queens, male alates, female alates, major workers, minor workers, eggs, larvae and pupae. This result corresponded to Lee *et al.* (2003)



Figs. 7-12: Fig. 7. Eggs of minor worker of *O. smaragdina* from both colonies; Fig. 8. Eggs of major worker of *O. smaragdina* from both colonies; Fig. 9. Larvae of female alate of *O. smaragdina* from both colonies; Fig. 10. Pupae of minor workers of *O. smaragdina* from both colonies; Fig. 11. Pupae of major workers of *O. smaragdina* from both colonies; Fig. 12. Pupae of female alate of *O. smaragdina* from both colonies.

where the *O. smaragdina* ants had a complete metamorphosis consisting of immature stages (eggs, larvae, and pupae) and adults with reproductive stage (dealate queen) and non-reproductive stage (workers). The workers of *O. smaragdina* were all females and had a dimorphism or bimodal size-frequency distribution known as major and minor workers (Wilson 1953; Greenslade 1972; Hölldobler & Wilson 1990). The specific function of each individual adult in a colony is determined by the existence of the caste system and this division of labour is important for the continuous survival of the colony (Lee *et al.* 2003). Contrary to the current study, Peng *et al.* (1998a; 1998b) reported that there were large numbers of major workers, eggs, early-instar larvae and some minor workers within each queen nest, but no pupae or medium-sized or large-sized larvae. Way (1963) also reported that the brood (immature stages) of *O. smaragdina* is not raised in 'pavilions'; the pavilions are constructed in the same way as nests where many homopterans are tended by ants, often several meters away from the nearest ant nest.

Only one dealate queen found in the KAFA colony and no dealate queen was found in the TI colony. This may be due to the KAFA colony was established much earlier than the TI colony. The nests which were taken from the TI colony were also fewer in numbers and smaller in size compared to the nests of the KAFA colony. Similar to the present study, Peng *et al.* (1998b) reported that young mango trees which were closer to the matured mango trees with well-established *O. smaragdina* colonies were found to have more dealate queen nests. After being inseminated by a male ant during nuptial flight, the winged queen shed her wing (Oster & Wilson 1978; Lokkers 1990). The queen would then begin to construct the first nest cell and rears its first brood of workers. Soon, the workers would take over the tasks of foraging and brood care, allowing the queen to confine herself to egg-laying (Oster and Wilson 1978). Therefore, the presence of a dealate queen in the KAFA colony showed that the colony was well-maintained compared to the TI colony.

The number of male alates in the KAFA colony was higher than the female alates might be due to the female alates could mate with more than one male during swarming (1384.38 ± 367.57 ; 80.00 ± 26.09). This result was supported by Schlüns *et al.* (2009) who reported that direct genotyping of the sperm carried by 77 Queensland queens and worker genotypic arrays of

established colonies of *O. smaragdina* showed that less than half of the queens mate only once, while some mate up to five times, which suggested that more males were involved during mating than the females. Similar behavior was also observed in *Formica subpolita* ants where the females controlled who they mated with and were observed to mate with up to 4 different males, before dispersing from swarm sites (O'Neill 1994). Female ants may mate just once, but multiple mating is apparently typical for many species (Hölldobler & Wilson 1990). Lee *et al.* (2003) explained that male ants have only one task, which is to inseminate the queen. They usually possess wings and mating can occur within the nest or outside the nest (swarming). Shortly after mating, the males die and the queens settle and establish new colonies (Schlüns *et al.* 2009; Lee *et al.* 2003).

For the female alates found inside the nests, the yellow color was also observed in the study of intercolony transplantation of *O. smaragdina* by Krag *et al.* (2010). They reported that the *O. smaragdina* can be categorized into the following distinct groups: larvae, pupae, light yellow callow workers and red mature workers. Lee *et al.* (2003) explained that a newly hatched adult which has not yet acquired its deep coloration is known as a callow. It will undergo coloration as it grows older. Therefore, it could be that the yellow colored female alates of the TI colony were newly emerged adults that had not yet acquired its deep coloration (callow) (Fig. 4). This result supported that the KAFA colony was established much earlier than the TI colony due to the presence of the matured female alates with greenish color in the KAFA colony. Our results also show that the number of female alates in the KAFA colony was higher than the TI colony (80.00 ± 26.09 ; 11.00 ± 5.08).

The higher number of major workers compared to minor workers discovered in the current study could be due to task allocation. The major workers have more tasks than the minor workers do and therefore more major workers would be needed (Lee *et al.* 2003). This result corresponds to previous studies which demonstrated that the major workers do virtually all of the foraging, defend the colony, care for the queen and assist in the care of the brood (Chapuisat and Keller, 2002), whereas the minor workers mostly remain inside the leaf nests and function as nurses of the brood studies (Hölldobler & Wilson 1978; 1990). This allocation of tasks to different castes of *O. smaragdina* creates an efficient society (Saarinen 2006).

The eggs were small and ellipse-shaped with a size around 0.5 mm x 1.0 mm. The eyes and mouth of the larvae within the eggs could be seen when they were observed under a magnifying glass. The pupae could be differentiated from the mature adults because they were white in color (Van Mele & Cuc 2007). The *O. smaragdina* colonies could produce a large number of “queen brood” every year. The “queen brood” refers to larvae and pupae, which are destined to become new queens as well as their last stage as imago virgin queens (Cesard 2004; Offenbergs & Wiwatwitaya 2010). The current study also showed that *O. smaragdina* ants built new nests within 14 days after their nests were taken. The new nests were located near to the nests which were taken for our study. Regarding this condition, Paimin and Paimin (2001) reported that under normal conditions, weaver ants have a quick population recovery with regeneration time between 17 and 24 days. Others reported it takes five days before new nests appear and around 20 days for the ants to produce new larvae (Cesard 2004).

A caste can be characterized as a set of individuals in a colony, morphologically distinct from other individuals and specialized in behavior which performs specialized task in the colony (Oster & Wilson 1978). The present study showed that different caste of *O. smaragdina* ants performed different but specific task to maintain their colony well. Hölldobler & Wilson (1990) stated a colony which is large enough to produce new, virgin queens known as “mature colony” and the efficiency of the mature colony is determined by the number of workers in each temporal caste at any given moment. This suggests that the KAFA colony in the current study was a mature colony of *O. smaragdina* with the presence of a dealate queen and more workers compared to the TI colony.

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